

258

Scoring Indicators

Apr-25

COURSE NAME :DIGITAL COMMUNICATION

P-19

COURSE CODE : 5043D

QID : 2109230104


PART A

I. Answer all the following questions in one word or sentence.

(9 x 1 = 9 Marks)

Max. marks

Q.No	Scoring Indicators	Split score	Sub Total	Total score
	PART A			9
I.1	• Impulse sampling. • Natural sampling. • Flat Top sampling		1	
I.2	Bit		1	
I.3	Simplex		1	
I.4	A synchronous communication system is a method of data transmission in which the sender and receiver are synchronized in time and share a common clock signal,		1	
I.5	Shannon's theorem gives the capacity of a system in the presence of noise $C = B \log_2 (1 + \text{SNR})$ b/s or $C = B \log_2 (1 + S/N)$ b/s		1	
I.6	Hamming code and Reed Solomon code		1	
I.7	Code Division Multiple Access		1	
I.8	PN sequence is a deterministic sequence of digital values that appears random but generated using mathematical algorithm.		1	
I.9	Orthogonal Frequency Division Multiplexing		1	
	PART B			24
II.1	The word Companding is a combination of Compressing and Expanding, which means that it does both. This is a non-linear technique used in PCM which compresses the data at the transmitter and expands the same data at the receiver. The effects of noise and crosstalk are reduced by using this technique			

II.2	<p>Non-uniform quantization, also known as non-linear quantization or companding quantization, is a quantization technique used in signal processing and data compression. Unlike uniform quantization, where the quantization intervals are evenly spaced, non-uniform quantization uses variable-sized quantization intervals to allocate more bits to represent the parts of the signal that require greater precision. This approach helps maintain higher fidelity for the important parts of the signal while saving bits for the less critical portion</p>			
II.3	<p>The conventional methods of communication used analog signals for long distance communications, which suffer from many losses such as distortion, interference, and other losses including security breach. • In order to overcome these problems, the signals are digitized using different techniques. The digitized signals allow the communication to be more clear and accurate without losses. • The digital signals consist of 1s and 0s which indicate High and Low values respectively</p> <div style="text-align: center;">  </div>			
II.4	<p>This distortion arises because of large dynamic range of the input signal.</p> <p>As can be observed from fig. 1, the rate of rise of input signal $x(t)$ is so high that the staircase signal can not approximate it, the step size "A" becomes too small for staircase signal $u(t)$ to follow the step segment of $x(t)$.</p> <p>Hence, there is a large error between the staircase approximated signal and the original input signal $x(t)$.</p> <p>This error or noise is known as slope overload distortion .</p>			

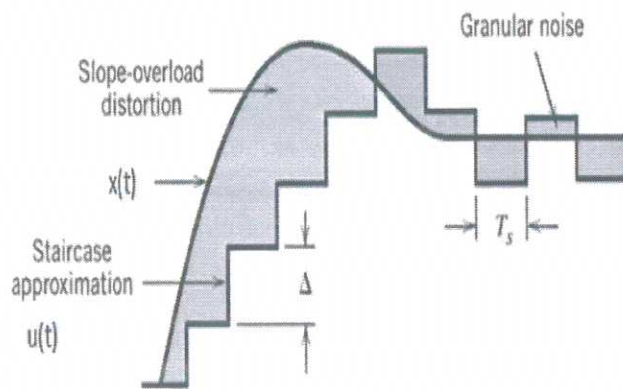


Diagram
(2)

II.5

- 1. It is used in a type of telephone line that uses ISDN (Integrated Services Digital Network) technology. }
- 2 It's a significant component of a telephone system.
- 3.TDM is a technique utilized in GSM or GlobalTDM is a technique utilized in GSM or Global System for Mobile Communication.
- 4. In SONET, time-division multiplexing, or TDM, is applied (Synchronous Optical Networking).

II.6

Given the generator matrix (G):

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 \end{bmatrix}$$

To calculate the parity check matrix (H), you need to take the transpose of the parity bits (the last three columns of G) and make them the rows of H. Here's the parity check matrix:

$$H = \begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

	1 0 1 1 0 0 1			
	This is the parity check matrix (H) for the (7,4) Hamming code with the given generator matrix (G).			
II.7	Frequency Hopping Spread Spectrum (FHSS) is a modulation technique used in wireless communication systems to spread the signal over a wide range of frequencies. FHSS involves rapidly changing the carrier frequency according to a specific pattern known to both the transmitter and receiver. This hopping pattern is synchronized to ensure that both the sender and receiver change frequencies in a coordinated manner.			
II.8	<p>Orthogonally spaced subcarriers are crucial in various communication and data transmission systems, especially in the context of Orthogonal Frequency Division Multiplexing (OFDM). Here are some reasons for their importance:</p> <ol style="list-style-type: none"> 1. Frequency Efficiency: Orthogonal subcarriers maximize the spectral efficiency of a communication system. They allow for efficient packing of data within the available bandwidth, ensuring that the channel is utilized optimally. Easy Implementation: The orthogonality of subcarriers simplifies the signal processing at both the transmitter and receiver ends. It enables efficient algorithms for modulation and demodulation, making OFDM a practical choice for various communication standards like Wi-Fi, LTE, and digital broadcasting. 2. Flexibility: Orthogonal subcarriers can be easily adjusted in terms of their spacing and number to adapt to different channel conditions, bandwidth constraints, and data rate requirements. 3. Low Interference: Since orthogonal subcarriers have minimal interference between them, they are less susceptible to external interference sources, making the system more robust in noisy. 			
II.9	A Rake receiver is a specialized receiver used in wireless communication systems, particularly in CDMA (Code Division Multiple Access) and spread spectrum			

	<p>technologies. It's designed to improve the reception of signals in multipath propagation environments where signals from a transmitter arrive at the receiver via multiple paths due to reflection, diffraction, and scattering. Here's a short note on the Rake receiver: A Rake receiver is named after its resemblance to a garden rake, as it collects and combines multiple delayed copies of the transmitted signal.</p>			
II.10	<p>Multicarrier communication, particularly exemplified by technologies like Orthogonal Frequency Division Multiplexing (OFDM), plays a significant role in modern telecommunications. Here are some key points highlighting the importance of multicarrier communication: 1. *Spectral Efficiency: 2. *Robustness to Frequency Selective Fading:* 3. *Data Rate Flexibility* 4 *Wireless Communication:* 5. *Reduced Intercarrier Interference</p>			
	PART C			42
III	<ul style="list-style-type: none"> • Low Pass Filter • This filter eliminates the high frequency components present in the input analog signal which is greater than the highest frequency of the message signal, to avoid aliasing of the message signal. • Sampler • This is the technique which helps to collect the sample data at instantaneous values of message signal, so as to reconstruct the original signal. • Quantizer • Quantizing is a process of reducing the excessive bits and confining the data. The sampled output when given to Quantizer, reduces the redundant bits and compresses the value. • Encoder • The digitization of analog signal is done by the encoder. It designates each quantized level by a binary code. The sampling done here is the sample-and-hold process. These three sections LPF,Sampler,andQuantizer will act as an analog to digital converter. Encoding minimizes the bandwidth used. • Regenerative Repeater 	Exp.4		

- This section increases the signal strength. The output of the channel also has one regenerative repeat reconstr
- streng
-
- wavefi
- circuit
-
- by the
- pass fi
- filter t
-
- digitiz
- it, and
- whole
- obtain

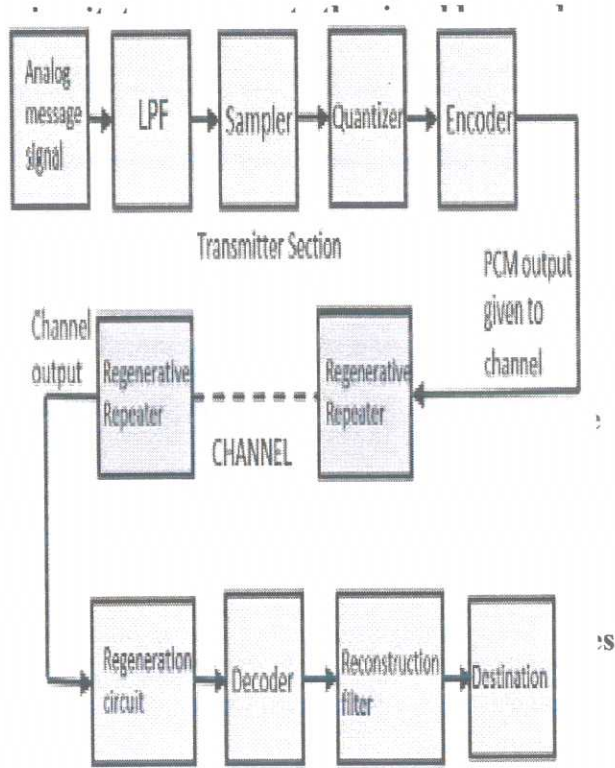


Diagram (3)

IV

- A larger step-size is needed in the steep slope of modulating signal and a smaller step size is needed where the message has a small slope. The minute details get missed in the process. So, it would be better if we can control the adjustment of step-size, according to our requirement in order to obtain the sampling in a desire fashion. This is the concept of Adaptive Delta Modulation

1. ***Analog Signal (x(t))*:** This is the continuous analog signal that you want to digitize using delta modulation. It is the input to the system.

2. ***Quantizer*:** The quantizer takes the continuous analog signal and samples it at regular intervals (this involves taking samples at specific time instants). It quantizes each sample into a binary output based on the difference (delta) between the sampled value and the predicted value (often referred to as the quantization level).

2. ***Quantizer*:** The quantizer takes the continuous analog signal and samples it at regular intervals (this involves taking samples at specific time instants). It quantizes each sample into a binary output based on the difference (delta) between the sampled value and the predicted value (often referred to

	<p>as the quantization level).</p> <p>3. *Predictor*: The predictor is responsible for estimating the next quantization level based on the previous quantized output. In simple delta modulation, this predictor might just remember the previous output and use it as the prediction.</p> <p>4. *Delta Modulator*: This component combines the quantizer and predictor. It computes the difference between the actual signal and the predicted value (delta) and quantizes it to produce a digital bit (1 or 0). This bit represents whether the actual signal is greater or less than the predicted value.</p> <p>5. *Digital Output (y(t))*: This is the digital representation of the analog signal produced by the delta modulator. It's a stream of binary bits that approximate the original analog signal. 6. *Decoder (Optional)*: In some cases, there may be a decoder on the receiving end to convert the digital output back to an analog signal for further processing or transmission. However, basic delta modulation may not require a dedicated decoder, as the digital output can be used directly.</p> <p>Here's a simplified textual representation of the block diagram:</p> <p>Analog Signal (x(t)) --> Quantizer --> Predictor --> Delta Modulator --> Digital Output (y(t))</p>			
V				

ASK	FSK	PSK
1) Information is in amplitude variations.	Information is in frequency variations.	Information is in phase variations.
2) Less Bandwidth as compared.	More Bandwidth as compared.	Less to moderate Bandwidth.
3) Poor Noise immunity.	Better Noise immunity.	Better Noise immunity.
4) Synchronization is not required.	Synchronization is not required.	Synchronization is essential.
5) Effect of DC is more.	Effect of DC component is less.	Effect of DC component is less.
6) More power required.	Moderate power required.	Less-moderate power required.
7) Low bit rate application	Moderate bit rate application.	High bit rate application.
8) Simple Implementation.	Moderately complex Implementation.	Very complex Implementation.

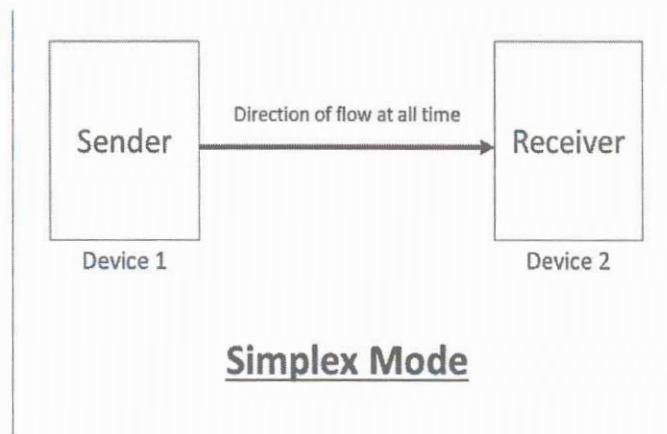
VI

The data transmission modes can be characterized in the following three types based on the direction of exchange of information:

1. Simplex
2. Half-Duplex
3. Full Duplex

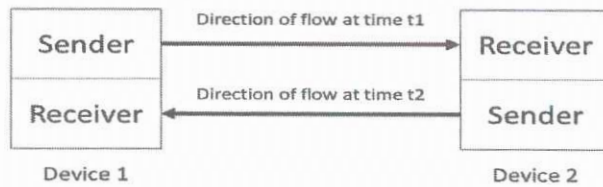
1. Simplex

Simplex is the data transmission mode in which the data can flow only in one direction, i.e., the communication is unidirectional. In this mode, a sender can only send data but can not receive it. Similarly, a receiver can only receive data but can not send it.



2. Half-Duplex

Half-Duplex is the data transmission mode in which the data can flow in both directions but in one direction at a time. It is also referred to as Semi-Duplex. In other words, each station can both transmit and receive the data but not at the same time. When one device is sending the other can only receive and vice-versa.



Half-Duplex Mode

VII

Synchronous and asynchronous data transmission are two methods used in communication systems1.

Synchronous Transmission:

- ***Timing:*** Synchronous transmission relies on a shared clock signal between the sender and receiver to synchronize data transfer. Both parties must agree on the timing in advance.

- ***Data Transfer:*** Data is sent in fixed, well-defined time intervals or frames. Each frame contains a specific amount of data, and transmission occurs at regular intervals.

- ***Efficiency:*** It is typically more efficient for high-speed, continuous data transfer, as there is no need to send additional control information for timing.

- ***Examples:*** Synchronous transmission is common in applications like voice communication and streaming media.

2. *Asynchronous Transmission:*

- ***Timing:*** Asynchronous transmission does not rely on a shared clock signal. Instead, each data character is accompanied by start and stop bits to indicate the beginning and end of a character.

- ***Data Transfer:*** Data is sent character by character, with variable time gaps between characters. This flexibility makes it suitable for sporadic or irregular data transmission.

- ***Efficiency:*** It is less efficient than synchronous transmission for continuous data streams because of the overhead from start and stop bits.

Examples:* Asynchronous transmission is often used

in applications where data is transmitted in small packets, such as text-based communication over serial ports.

In summary, synchronous transmission is best suited for applications requiring continuous, high-speed data transfer with strict timing requirements, while asynchronous transmission is more flexible and appropriate for sporadic or variable-speed data transfer where precise timing is not critical.

VIII

SL.NO	TDM	FDM
1.	TDM stands for Time division multiplexing.	FDM stands for Frequency division multiplexing.
2.	TDM works with digital signals as well as analog signals.	While FDM works with only analog signals.
3.	Wiring or chip of TDM is simple.	While it's wiring or chip is complex rather than simple.
4.	In TDM, synchronization pulse is necessary.	While in it Guard band is necessary.
5.	Cross talk problem is not severe	Cross talk is severe
6.	In TDM, time sharing takes place.	While in this, frequency sharing takes place.
7.	More Efficiency	Less Efficient

IX

To determine whether the received 7-bit Hamming code is correct or incorrect, we need to perform parity checks. In this case, we assume even parity, meaning that the number of '1' bits in each group of bits (including the parity bit) should be even.

Let's check the received code: (1 1 0 0 0 1 1 0 1)

1. *Check Parity Bit P1 (Position 1)*: Check bits 1, 3, 5, 7 for even parity.

- Bit 1 is 1 (odd).
- Bit 3 is 0 (even).
- Bit 5 is 0 (even).
- Bit 7 is 1 (odd).

The parity of these bits is odd, which doesn't match the expected even parity. This indicates that there is an error in bit 1 (P1).

	<p>2. *Check Parity Bit P2 (Position 2)*: Check bits 2, 3, 6, 7 for even parity.</p> <ul style="list-style-type: none"> - Bit 2 is 1 (odd). - Bit 3 is 0 (even). - Bit 6 is 1 (odd). - Bit 7 is 1 (odd). <p>The parity of these bits is odd, which doesn't match the expected even parity. This indicates that there is an error in bit 2 (P2).</p> <p>3. *Check Data Bits*: We now have the positions of the erroneous bits (P1 and P2). Let's check the data bits (4, 5, 6):</p> <ul style="list-style-type: none"> - Bit 4 is 0. - Bit 5 is 0. - Bit 6 is 1. <p>There are no errors in the data bits.</p> <p>4. *Error Correction*: To correct the errors, we can flip the bits at positions 1 and 2.</p> <p>Now, let's correct the received code: (1 0 0 0 0 1 1 0 1) 1) The corrected code is (10000110), and it should match the original transmitted 7-bit Hamming code.</p> <p>So, the received code was incorrect, but we were able to identify and correct the errors in bits 1 and 2 to obtain the correct 7-bit Hamming code.</p>			
X	<p>Coding, also known as programming, is a crucial skill in today's digital age for several reasons:</p> <p>1. *Automation*: Coding allows you to automate</p>			

tasks and processes. This can range from simple scripts that rename files in a folder to complex algorithms that control autonomous vehicles. Automation can significantly increase efficiency and reduce human error.

2. ***Problem Solving***: Coding is a powerful tool for problem-solving. It enables you to break down complex problems into smaller, manageable parts and develop step-by-step solutions. This skill is valuable in various fields, including science, engineering, finance, and healthcare.

3. ***Innovation***: Many of the technological innovations that shape our world rely on coding. From the apps on your smartphone to advancements in artificial intelligence, coding is at the heart of technological progress. Learning to code empowers you to be a part of this innovation.

4. ***Career Opportunities***: Coding skills are in high demand across industries. Proficiency in coding opens up a wide range of career opportunities, from software development and data analysis to cybersecurity and game design. It can also lead to well-paying jobs.

5. ***Creativity***: Coding is a creative outlet. It allows you to turn your ideas into tangible digital products, whether it's a website, mobile app, video game, or digital art. This creative aspect can be personally fulfilling.

6. ***Digital Literacy***: In an increasingly digital world, understanding how software works is a form of digital literacy. Coding helps you understand the technology you use daily, making you a more informed and empowered user.

7. ***Education***: Coding is increasingly integrated into educational curricula. It teaches valuable skills

	<p>such as logical thinking, problem-solving, and attention to detail. These skills are transferable to many areas of life.</p> <p>8. *Research and Analysis*: In fields like science and social sciences, coding is essential for data analysis and modeling. Researchers use coding to analyze large datasets, simulate experiments, and make predictions.</p> <p>9. *Personal Projects*: Whether you want to build a personal website, develop a mobile app, or automate tasks in your daily life, coding gives you the ability to turn your ideas into reality without relying on others.</p>			
XI	<p>Hamming codes are a family of error-correcting codes named after their inventor, Richard Hamming. They are used in digital communication systems to detect and correct errors that can occur during data transmission. Hamming codes are particularly popular in computer memory systems and are designed to correct single-bit errors and detect two-bit errors in data.</p> <p>Here's an explanation of how Hamming codes work:</p> <p>1. *Adding Redundancy*: Hamming codes work by adding extra bits (redundancy) to the original data bits. These extra bits are carefully chosen to provide error detection and correction capabilities.</p> <p>2. *Parity Bits*: In a basic Hamming(7,4) code, which is one of the simplest forms, you start with a 4-bit data word. Three additional bits are added to create a 7-bit codeword. These three extra bits are parity bits that provide error detection and correction.</p> <p>3. *Parity Bit Placement*: The placement of these parity bits is crucial. They are placed at positions that are powers of 2 (1, 2, and 4) in the codeword.</p>			

	<p>The remaining bits (positions 3, 5, 6, and 7) are used for the data.</p> <p>4. *Parity Calculation*: Each parity bit is calculated based on a specific combination of data bits. For example:</p> <ul style="list-style-type: none"> - Parity bit 1 (at position 1) checks data bits 1, 3, 5, and 7. - Parity bit 2 (at position 2) checks data bits 2, 3, 6, and 7. - Parity bit 4 (at position 4) checks data bits 4, 5, 6, and 7. <p>5. *Error Detection*: When the codeword is received, the receiver recalculates the parity bits using the received data bits. If any of the calculated parity bits doesn't match the received parity bit, it indicates an error.</p> <p>6. *Error Correction*: Hamming codes can not only detect errors but also correct them when a single-bit error occurs. The receiver can use the position of the erroneous parity bit to identify and correct the erroneous data bit.</p> <p>Hamming codes are widely used because they are relatively simple to implement and provide a good balance between error detection and correction capabilities. However, they are limited in their ability to correct multiple errors within the same codeword. More advanced error-correcting codes like Reed-Solomon codes are used when higher levels of error correction are required.</p>			
XII	<p>It appears there might be a typographical error in the generator matrix you provided. It should be a 6x3 matrix for a (6,3) code. The matrix you provided seems to be 3x6. Assuming you meant:</p> $G = 1 0 0 0 1 1 $			

| 0 1 0 1 0 1 |

| 0 0 1 1 1 0 |

This is a standard generator matrix for a (6,3) binary Hamming code.

To determine the codewords, you can perform matrix multiplication with all possible 3-bit message vectors (since it's a (6,3) code, you encode 3-bit messages into 6-bit codewords). Here are the codewords:

1. Message: [0 0 0]

Codeword: [0 0 0 0 0 0]

2. Message: [0 0 1]

Codeword: [0 0 1 0 1 1]

3. Message: [0 1 0]

Codeword: [0 1 0 1 0 1]

4. Message: [0 1 1]

Codeword: [0 1 1 1 1 0]

5. Message: [1 0 0]

Codeword: [1 0 0 1 1 0]

6. Message: [1 0 1]

Codeword: [1 0 1 1 0 1]

7. Message: [1 1 0]

Codeword: [1 1 0 0 1 1]

	<p style="text-align: center;">8. Message: [1 1 1]</p> <p style="text-align: center;">Code word: [1 1 1 0 0 0]</p> <p style="text-align: center;">These are the code words generated by the given (6,3) Hamming code with the provided generator matrix.</p>			
<p style="text-align: center;">XIII</p>	<p>FDMA, or Frequency Division Multiple Access, is a channel access method used in telecommunications to share a transmission medium, such as a radio frequency band or a cable, among multiple users. FDMA is commonly employed in analog and digital communication systems, including radio broadcasting, satellite communication, and older-generation cellular networks.</p> <p style="text-align: center;">Here's how FDMA works:</p> <ol style="list-style-type: none"> 1. *Frequency Division*: In FDMA, the available frequency band is divided into multiple non-overlapping subchannels or frequency slots. Each subchannel has a specific frequency range allocated to it. These subchannels are often referred to as "carriers." 2. *Analog and Digital Communication*: FDMA can be used in both analog and digital communication systems. In analog systems, each user's voice or data signal is modulated onto their assigned carrier frequency. In digital systems, users' digital data streams are divided into time slots or code sequences before modulation and transmission. 3. *Efficiency*: FDMA can be efficient when the bandwidth requirements of users vary. Users with high data rates or greater bandwidth needs can be allocated wider frequency bands, while those with lower requirements can be assigned narrower bands. This flexibility in bandwidth allocation can help optimize resource usage. 			
<p style="text-align: center;">XIV</p>	<p>Direct Sequence Spread Spectrum (DSSS) is a</p>			

modulation technique used in wireless communication to spread the data signal over a much wider bandwidth than the original signal. The primary purpose of DSSS is to provide resistance against interference and to enhance security in data transmission. Here's how DSSS works and some of its key characteristics:

1. ***Signal Spreading***: In DSSS, the data signal is spread over a much wider frequency band by multiplying it with a higher-rate spreading code (also known as a chip sequence or spreading sequence). This spreading code is a pseudorandom binary sequence with a much higher data rate than the original signal.
2. ***Increased Bandwidth***: The multiplication of the data signal by the spreading code results in a signal with a much higher bandwidth. This means that the transmitted signal occupies a wider frequency spectrum than the original data signal. This wide bandwidth is what provides DSSS with its resistance to interference.
3. ***Interference Resistance***: DSSS signals appear as noise to narrowband interference because they are spread over a wide frequency range. This makes it difficult for narrowband interference (such as other signals or noise) to disrupt the communication, as the signal is spread out over a broader spectrum.
4. ***Processing Gain***: DSSS achieves its interference resistance through a concept called processing gain. Processing gain is the ratio of the spread bandwidth to the original data bandwidth. The higher the processing gain, the more resistant the DSSS signal is to interference. This processing gain can be adjusted to meet the desired level of interference resistance.
5. ***Security***: DSSS provides a level of security by spreading the signal with a unique spreading code at

the transmitter. The receiver, which knows the spreading code, can despread the received signal to recover the original data. This makes it difficult for unauthorized parties to intercept or decode the signal without knowledge of the spreading code.

6. *Multipath Fading Mitigation*: DSSS can also help mitigate the effects of multipath fading in wireless communication. The spread signal tends to have a better chance of arriving intact at the receiver even if there are multiple reflected paths.